Mitigation Reef Plan

Phipps Ocean Park Beach Restoration Project Mitigation Reef Plan

1 - Introduction

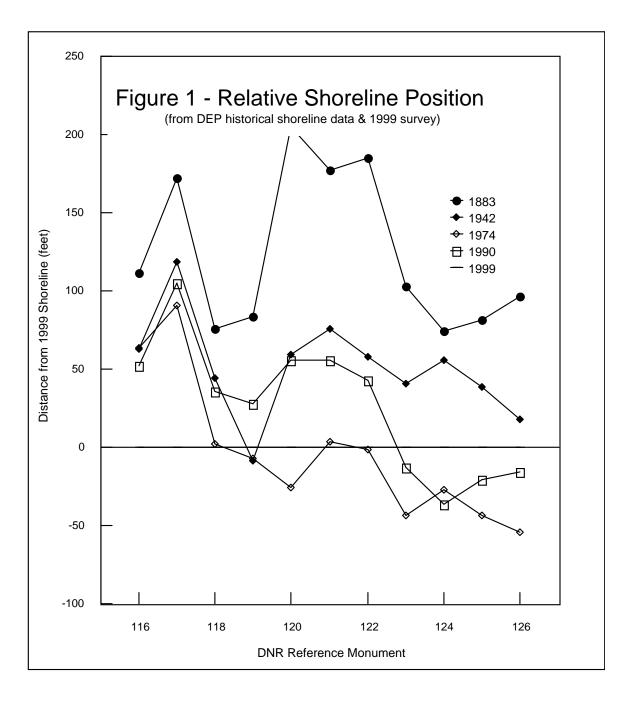
This document has been prepared in compliance with Specific Conditions of the State of Florida Department of Environmental Protection (FDEP) permit No. 0165332-001-JC issued March 14, 2001 for the Phipps Ocean Park Beach Restoration Project. Specifically, this document provides a revised Reef Mitigation Plan, as cited in Specific Condition 5, and additional information required prior to FDEP issuance of the Notice to Proceed for construction of the mitigation reef (Specific Conditions 13, 15a, and Monitoring Required, Conditions 2a and 2b). In addition, this document supplements the "Joint Coastal Permit" (JCP) Application submitted to the U.S. Army Corps of Engineers (USACE) for the Project.

The proposed Phipps Ocean Park Beach Restoration Project includes the placement of up to 1.5 million cubic yards of sand to restore 1.9 miles of beach within the Town of Palm Beach immediately south of Sloan's Curve. The Project has been designed to minimize hardbottom impact and avoid extensive exposed hardbottom north of the Project area. As designed, the Project is expected to directly impact ephemeral near shore hardbottom that is located immediately adjacent to the shoreline within the Project area.

The Phipps Ocean Park Project area is about 9 miles south of Lake Worth Inlet and within the area of influence of the downdrift sediment deficit caused by the inlet jetties. In addition, much of the shoreline between the inlet and Phipps Ocean Park is fronted by armoring structures including rock revetments, seawalls, and groins. In combination with the effects of Lake Worth Inlet, the armoring structures have caused a longshore transport deficit to the Project area and have resulted in erosion and the exposure of near shore hardbottom including in the Project Area. Based on DEP historical shoreline data, significant shoreline erosion has occurred since construction of the jetties at Lake Worth Inlet in 1925. Within the Project area, this erosion, as illustrated in the relative shoreline positions in Figure 1, has resulted in exposing underlying hardbottom. To offset the erosion effects of the Inlet and the adjacent armored shoreline, it is necessary to replace sand on the beach resulting in unavoidable impacts to nearshore hardbottom that has been exposed as a result of the severe sediment deficit.

The proposed Project is anticipated to bury all nearshore hardbottom within the Project area due to the fact that this exposed rock occurs very close to shore in the surf zone. Due to the proximity of the hardbottom to the existing shoreline, reduction in the design berm width would not minimize the extent of hardbottom impacts. As such, the impacts to nearshore hardbottom are unavoidable.

The culmination of the monitoring effort on the natural nearshore hardbottom in the vicinity of the project and the mitigation reef will be to summarize all data in an article suitable for publication in the peer-reviewed literature.



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To provide for mitigation of nearshore hardbottom impacts, FDEP Permit No. 0165332-001-JC issued March 14, 2001 requires the following:

Specific Condition 13: "The permittee shall construct a minimum of 3.1 acres of artificial reef as mitigation for impacts to 3.1 acres of natural nearshore hardbottom. The following procedures shall be adhered to for the construction of the artificial reef mitigation work:

a. Construction of the artificial reef shall be completed at least 6 months prior to the commencement of construction of the beach nourishment project."

<u>Permittee Response</u>: The mitigation reef construction will be completed six months prior to the start of construction of the beach nourishment project. Reef construction is expected to begin in April 2004 and be completed by June 2004. Construction of the beach fill component of the project will begin on or about December 15, 2004.

"b. Prior to beginning construction of the artificial reef, the permittee shall submit a plan view drawing identifying the surveyed coordinates of the artificial reef construction sites and all work spaces (staging areas, boat access corridors, etc.) to be used to construct the artificial reefs. The drawing shall include all hardbottom areas within 1,000 ft. of the artificial reef construction sites. This information shall be provided in both paper and electronic format. The work conducted adjacent to existing" (exposed) "hardbottom areas shall be performed in a manner that avoids impacts to existing" (exposed) "hardbottom. All artificial reef construction equipment shall be confined to the identified, buoyed work spaces. Artificial reef construction shall not begin until the Department approves the work spaces."

<u>Permittee Response</u>: Compliance with this condition is assured and will be specified in the Proposed Artificial Reef Construction Drawings and Technical Specifications.

"c. The information in item (b) above shall be submitted to the following agencies:

DEP - OBCS, Mail Station 300
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

DEP Southeast District Office Submerged Lands and Environmental Resources 400 North Congress Avenue West Palm Beach, Florida 33401

FWC - Artificial Reef Program 620 South Meridian Street, Box MF-MFM Tallahassee, Florida 32399-1600 Palm Beach County DERM 3323 Belvedere Road, Bldg. 502 West Palm Beach, FL 33406-1548

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FWC – BPSM Office of Environmental Services 620 South Meridian Street Tallahassee, Florida 32399-1600" Heinz J. Mueller, Chief (SEIS Request) U.S. EPA, Region 4 Office of Environmental Assessment Atlanta Federal Center 61 Forsyth St. Atlanta, Georgia, 30303

Ron Miedema (SEIS Request)
U.S. Environmental Protection Agency
Water Management Division
South Florida Office
400 N. Congress Avenue, Suite 120
West Palm Beach, FL 33401

Andreas Mager, Jr. (SEIS Request) National Marine Fisheries Service SE Regional Office 9721 Executive Center Drive N St. Petersburg, FL 33702

John Wrublik (SEIS Request) U.S. Fish & Wildlife Service 1339 20th Street Vero Beach, FL 32960 Penny Cutt, Project Manager U.S. Army Corps of Engineers 4400 PGA Blvd., Suite 500 Palm Beach Gardens, FL 33410

<u>Permittee Response</u>: The Drawings, which contain items described in item (b), have been submitted to the above agencies.

"d. Prior to the placement of any reef building material in the water at the mitigation site, the limits of the reef construction area shall be marked with buoys. If this work is to be conducted at night, the buoys shall be lighted."

<u>Permittee Response</u>: Compliance with this condition is assured and will be depicted in the construction drawings that depict the mitigation reef construction cells.

"e. The reef building materials shall be transported to the mitigation site by barge. Materials shall be lifted over the side of the barge and placed into the proper location by a pre-approved method of placement."

<u>Permittee Response</u>: Compliance with this condition is assured and will be specified in the Proposed Artificial Reef Construction Drawings and Technical Specifications.

"f. The artificial reef materials shall consist of clean limestone boulders. Reef construction materials shall be inspected by the permittee or their designee prior to loading onto work barges. Debris and sources of pollution shall be removed from the material prior to its placement onto the work barges. Rebar, steel, or other similar protruding materials shall not be included in the reef construction materials."

<u>Permittee Response</u>: Compliance with this condition is assured and will be specified in the Proposed Artificial Reef Construction Drawings and Technical Specifications.

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"g. The permittee shall ensure that the artificial reef is constructed to mimic the natural hardbottom in the project area. The artificial reef will contain between 1 to 4 feet vertical relief (greater relief is authorized only if the permittee provides the Department with documentation of the need to meet stability criteria or, on a temporary basis, to compensate for immediate subsidence), overhanging ledges, and crevices. The reef materials shall be placed in shore parallel formations with the total artificial reef surface area coverage of 3.1 acres. The method used to calculate this acreage shall be the same method that was used to measure the acreage of hardbottom impact, with respect to the inclusion of sand pockets within the reef tracts. Methods of rock surface area calculation shall be provided to the Department with each monitoring report."

<u>Permittee Response</u>: Compliance with this condition will be reflected in the Proposed Artificial Reef Construction Drawings.

"h. Following the completion of the placement of reef construction materials, the permittee shall use remote sensing techniques to survey the artificial reef sites to verify that the required reef area has been created and provides the appropriate average relief as indicated in the permit. If the remote sensing techniques indicate the artificial reef does not meet or exceed the approved mitigation plan, the permittee shall alter the reefs as needed and conduct additional surveys to verify that the permit requirements for artificial reef construction have been satisfactorily completed."

<u>Permittee Response</u>: As provided herein, the permittee will use remote sensing techniques (on-site inspection, video documentation and comparative aerial photography analysis) to survey the artificial reef sites to verify that the required reef area has been created and provides the appropriate average relief as indicated in the permit.

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2 - Natural Nearshore Hardbottom Characteristics

<u>Extent of Hardbottom</u>: The quantity and quality of naturally occurring nearshore hardbottom in the Project area fluctuates seasonally and with storm events. This section addresses the character and temporal variation in the extent of the natural nearshore hardbottom in the Project area.

On December 29, 1999 controlled aerial photography was obtained and rectified for the Project area including DNR Reference Monuments R-113 to R-128 (*map domain*). Continental Shelf Associates, Inc. (CSA) provided "ground truthing" of the aerial photography and characterization of fish and biological communities. On January 13, 2000, CSA conducted video transects along DNR monuments R-113 to R-124 and at mid-points between water depths of 4 feet to 30 feet. Within the Project area, these transects indicated minimal hardbottom at these depths. On February 29, 2000, CSA performed mapping of the hardbottom along the Project area shoreline between DNR monuments R-116 and R-124 (a) "by walking the perimeter of the features with the portable DGPS antenna" with a video camera and (b) by a longitudinal transect along the eastern limits of hardbottom. The methods, data analyses, and results are documented in a report by CSA titled "*Pre-Construction Hardbottom Mapping and Characterization Survey for Phipps Ocean Park - Palm Beach Florida*", dated March 17, 2000.

The results indicate that, in 2000:

- immediately north of the Project area, an extensive (200± feet wide) band of hardbottom existed including soft coral, worm reef, and algae;
- within the Project area, a narrow (typically <50± feet) band of sporadic hardbottom existed along the shoreline dominated by worm reef and algae;
- immediately south of the Project area, very little hardbottom existed.

Within the Project area, on February 29, 2000, the hardbottom consisted primarily of low relief exposed rock, scattered rock in sand, and sand veneered rock adjacent to the shoreline. Some rock with vertical relief greater than 2 feet existed between monuments R-117.5 to R-122. For the entire project area, the December 1999 aerials indicate 4.24 acres of exposed, sub-tidal, and biologically productive hardbottom below the Mean Low Water Line (MLW), which corresponds to elevation -1.1 N.G.V.D.

Table 1 summarizes exposed hardbottom areas interpreted from available historical aerial photographs below the 1999 MLW. Hardbottom maps or aerials for 1971, 1983, 1985, 1991, 1992, 1993, 1994, 1997, and 1998 were provided by Palm Beach County DERM. Coastal Tech determined historical hardbottom areas (acres) within the Project area from these maps and aerials - except for the 1971 aerial, which has inadequate quality for hardbottom interpretation.

The data indicate that the area of exposed hardbottom in the Project area has been highly variable. This variability is likely weather dependent. The area of exposed hardbottom appears to have increased over time, which is probably attributable to the increased erosion that has occurred in the Project area since the 1987 revetment construction along the adjacent updrift shoreline. Erosion has exposed the hardbottom that now exists in shallow water along and adjacent to the shoreline.

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Table 1 - Historical Exposed Hardbottom

		Total Hardbottom	Average Hardbottom	Exposure Duration	Hardbottom Exposure
Date	Season	(acres)	(acres)	(days)	(acre-days)
Sep-83	Summer	0.57			
			1.53	547	834
Mar-85	Winter	2.48			
			1.57	2344	3677
Aug-91	Summer	0.66			
			0.82	366	298
Aug-92	Summer	0.97			
			0.97	212	206
Mar-93	Winter	0.97			
			1.38	122	168
Jul-93	Summer	1.79			
			2.30	396	911
Aug-94	Summer	2.81			
			2.90	1096	3178
Aug-97	Summer	2.99			
			3.94	304	1196
Jun-98	Summer	4.88			
	1.4.7	4 0 4	4.56	576	2627
Dec-99	Winter	4.24	T- (- !	5000	40000
		T:	Total:		13096
Time Averaged Acres: 2.20					

The December 1999 aerial photography indicates that 4.24 acres of hardbottom were exposed and located below the MLW. Due to the effects of storm events, time-averaging techniques are utilized to characterize the extent of expected impacts to nearshore hardbottom. Table 1 summarizes the time-averaged exposed hardbottom over a period of nearly 28 years.

To avoid bias in the time-averaging procedure, FDEP required that the winter aerials be excluded from the analysis to factor out seasonal fluctuations, and aerials greater than five years old can be excluded to factor out historical biases. Time-averaging summer time only surveys dating back to August 1994 yields a time-averaged hardbottom impact of 3.1 acres based on consideration of the more recent data as summarized in Table 2.

The DEP permit (No. 0165332-001-JC) identifies that the Project will impact about 3.1 acres of hardbottom. A 3.1-acre artificial reef is proposed to offset impacts to the natural nearshore hardbottom at a 1:1 mitigation ratio.

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	Table 2 – DEP	Time Averaged	Historical Exp	posed Hardbottom
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		Total Hardbottom	Average Hardbottom	Exposure Duration	Hardbottom Exposure
Date	Season	(acres)	(acres)	(days)	Exposure (acre-days)
Aug-94	Summer	2.81			
			2.90	1096	3178
Aug-97	Summer	2.99			
			3.94	304	1196
Jun-98	Summer	4.88			
			2.99	792	2368
Aug-00	Summer	1.10			
	Total: 2192 6743				6743
Time Averaged Acres: 3.08					

<u>Character of Hardbottom</u>: Opportunistic sessile organisms such as blue-green algae, barnacles, and false limpets are most common on the *ephemeral* hardbottom. The *resilient* hardbottom supports more diverse and productive biological communities including macroalgae (*Caulerpa* spp., *Dictyota* spp., and *Padina* sp.), sponges (*Cliona* spp., *Dysidea* sp., *Monanchora* sp., and *Ircinia* spp.), sabellariid worm rock (*Phragmatopoma lapidosa*), and several hardy coral species (*Muricea* sp., *Pseudopterogorgia* sp., *Pterogorgia* sp., and *Siderastrea radians*). This *resilient* hardbottom also provides nursery habitat for many species of juvenile fish which could include grunts, margates, wrasses, parrotfishes, damselfishes, jacks, snappers, and clinids.

3 - Mitigation Reef

General: Although the assemblage of fish species that will utilize the artificial reef is expected to be the same as the assemblage currently utilizing the nearshore hardbottom, utilization of the two habitats by different age classes is not well understood. Studies have shown that larval fish of some species either select or have higher survival rates in nearshore hardbottom. However, it is not known if the difference in depth, wave energy, and topography between impacted hardbottom and the artificial reef are enough to make a difference for these larval fish. Given the limitations associated with constructing an artificial reef that more closely simulates the low relief, ephemeral hardbottom in the surf zone (including stability, safety, and economic factors), the mitigation reef is to be located beyond the surf zone in slightly deeper water and with boulders over rock substrate that has on occasion been historically exposed but is now covered by a veneer of sand. Attached are proposed drawings for the artificial reef.

The low relief, ephemeral hardbottom in the surf zone may provide essential habitat to some component of the nearshore fish community that may not be provided by the mitigation reef. In order to address this potential, the Town of Palm Beach (permittee) will conduct a study to compare the utilization of the two habitat types as identified in the monitoring section of this document. In addition to fish species and age classes, the study will also look at colonization by macroalgae and utilization by marine turtles as feeding habitat.

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Stability Analysis: The stability of the material proposed to construct the resilient mitigation reef was investigated under energy conditions associated with a 20-year return period storm surge. As suggested by FDEP staff, the analysis was performed using the *Artificial Reef Stability Analysis Software* developed by Paul Lin & Associates, Inc. (Lin, 2000). The wave energy affecting the rock units is strongly dependent on the degree to which they project up into the water column (lift and vertical component of inertia) and the overall surface area upon which the horizontal forces can operate (drag and horizontal component of inertia). However, because the goal of the stability analysis is to determine the minimum stable rock size for the proposed depth of placement, their dimensions and heights above the bottom are not known a priori. This analysis determines the stable rock size for various depths using the *Artificial Reef Stability Analysis Software*. The rock to be placed is assumed to be spherical by the software. Table 3 lists the input parameters used in the stability analysis:

Table 3. Input Parameters Used in the Stability Analysis

Parameter	Value	Comment	
Design Storm	20-year storm	prescribed by DEP rules	
Water depth at reef, d _s (above rock substrate)	from 9 to 15 feet	depths at site	
Deepwater wave height, H _o	21 feet	prescribed by Software	
Wave period, T	9 seconds	prescribed by Software	
Rock unit weight	≥ 135 pcf	Florida Limestone	

Table 4 presents the results of the stability software calculations for water depths corresponding to –9 to -15 feet N.G.V.D. in one-foot depth increments. The rock weights and sizes shown are those minimums, which the software predicts would be stable for the exposure condition. Lin (2000) indicates that there is an approximate 25 percent factor of safety in the calculations to address various assumptions about shape and numerical coefficients.

Table 4 - Stability Analysis Summary Chart

Water Depth (feet)	Minimum Diameter (feet)	Prescribed Diameter (feet)	Weight (tons)
9	3.0	3.0	0.95
10	3.2	3.5	1.51
11	3.6	4.0	2.26
12	3.8	4.0	2.26
13	4.2	4.5	3.22
14	4.4	4.5	3.22
15	4.8	5.0	4.42

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The calculations necessarily include certain assumptions about the reef materials, which may not accurately reflect the conditions during actual construction. The rock to be placed is assumed for calculation to be spherical when in practice it is not spherical, but may have a long dimension-to-short dimension ratio in the range of 2 or 3 to 1. In addition, the calculated stable rock weights and diameters are rather more precise than can be controlled by a quarry. In practice, allowance for a range of weights and sizes is prescribed with the majority (>50%) of the stone sizes being the prescribed weight or larger.

<u>Sand Veneer</u>: Jet probe results in the area of the proposed resilient reef show a relatively thin veneer of sand overlying a rock substrate. This sand veneer ranges from about 0.5 to 4 feet in thickness over the proposed mitigation area. The placed rock is expected to settle into the sand to the rock substrate below or the sand may be scoured away by wave-induced turbulence. This settlement could temporarily reduce the final net rock exposure. This settlement would inherently increase stability because of a "locking" effect; this effect is ignored in the calculation, but it would provide some additional factor of safety in the results.

In order to ensure that most of the rock surface area remains available for colonization and to promote the creation of 'edge effects,' the rock shall not be placed uniformly over the mitigation site, but shall be placed in a series of shore-parallel cells. The boulders in each cell will be placed randomly - without respect to axis orientation and will cover approximately 95% of the cell surface area. This random placement will have the effect of increasing the 'dimensionality' of the structure without actually layering the rock.

Effects on Adjacent Shoreline: The concern has been expressed that the mitigation reef may have a "breakwater effect" on the adjacent shoreline, producing unintended alteration of incident wave energy and an erosion-accretion shadow. It is generally accepted in the design of detached breakwaters that the structure must extend an appreciable distance from the bottom up into the water column in order to disrupt the wave form and alter the fluid velocities, thereby changing the unit energy transmitted. The amount of the water column, which must be intercepted, depends on factors such as wave steepness, the width of the structure in comparison to incident wavelength, the friction coefficient/porosity of the material, general bottom slope in the area and similar details. However, laboratory tests and experience have shown that structures which intercept less than 40 to 50 percent of the water column rarely produce any effect on the waves and therefore do not result in any shoreline response. It can be seen from Table 4 that even if the full rock diameter were assumed to be exposed, the reef would not occupy enough of the water column to appreciably transform incident waves. It can be further noted that these height-depth values are for 'average' conditions, which do not produce the major shoreline altering wave energy. When more energetic and significant wave conditions occur, they generally are associated with increases in water level and therefore proportionately less influence from the fixed-height structure.

<u>Construction Schedule</u>: The mitigation reef construction will be completed six months prior to the start of construction of the beach nourishment project. Reef construction is expected to begin in April 2004 and be completed by June 2004. Construction of the mitigation reef prior to fill placement will allow for colonization of the reef such that biological productivity of the mitigation reef will be comparable to the impacted reef by the time of beach fill construction.

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4 – Monitoring Plan

<u>FDEP Permit Monitoring Requirements Relevant to the Mitigation Reef.</u> The FDEP permit includes the following monitoring requirements for the Phipps Ocean Park Project Mitigation Reef. These monitoring requirements also include Florida Fish & Wildlife Conservation Commission (FFWCC) and National Marine Fisheries Service (NMFS) monitoring requirements and forthcoming USACE monitoring requirements.

"Biological Monitoring". The permittee shall submit a biological report within 90 days of completion of the post-construction survey and annually thereafter. Following each semi-annual survey, a brief letter report will be provided notifying FDEP that the survey had been conducted and noting any unusual observations or potential impacts visible at the time of the survey. The annual reports will summarize the data from each semiannual survey and provide comparisons to pre- and other post construction surveys. The report shall summarize the results of the biological surveys and the monitoring of the mitigation areas and identify any adverse impacts that might be attributable to the project. Each report shall compare the current conditions to a) the pre-construction baseline survey, b) the first postconstruction survey, and c) any previous semi-annual survey(s) (where applicable). Each report shall contain an analysis and discussion of the video documentation in regards to any burial, subsidence, sedimentation, or trauma that has affected the marine algae, coral, sponges, or other related biological communities. In addition to the standard monitoring of physical stability and taxonomic lists of species, the plan should include ecological comparisons to adjacent hardbottom reefs that examine variables such as indices of recruitment for larval/iuveniles, predation rates and prey vulnerability, and size structure of fish and selected invertebrates.

- a. Natural nearshore hardbottom: To verify that the project will not have an adverse affect on the natural nearshore reef located approximately 1,000 ft. to the north and south of the project, underwater surveys, with video documentation, of the nearshore hardbottom located north of the project area shall be taken immediately prior to construction, immediately after construction, and annually thereafter for a period of five years, unless otherwise determined by the Department. DGPS navigational coordinates of the dives shall be referenced on the video transects and overlaid on recent aerial photography.
- b. Mitigation Artificial Reef. Underwater surveys of the mitigation artificial reef, with video documentation, shall be taken immediately prior to construction, immediately after construction, and annually thereafter for a period of five years, unless otherwise determined by the Department. DGPS navigational coordinates of the dives shall be referenced on the video transects and overlaid on recent aerial photography.

<u>Introduction – Phipps Mitigation Reef Monitoring Plan Detail</u>: The mitigation reef monitoring plan has been developed to specifically comply with the monitoring requirements set forth in the FDEP Permit (excerpted above) and to be consistent with comments received on the Monitoring Program in the public review of the Supplemental Environmental Impact Statement (SEIS) for the Phipps Ocean Park Project.

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In general, the monitoring program, under the long term management of the Town of Palm Beach, is designed to compare attributes of epibiotal and fish assemblages colonizing the mitigation reef with those found on the two types of nearshore hardbottom found in the area: resilient and ephemeral. Resilient hardbottom is found in water depths ranging from 3 to 10 m (10 to 33 ft) and is consistently exposed (rarely covered with sand). Ephemeral hardbottom occurs in water depths ranging from 0 to 3 m (0 to 10 ft) and is regularly buried and uncovered by sand.

The Monitoring Plan is thus intended to compare three reef types: (1) the mitigation reef, (2) ephemeral hardbottom areas, and (3) resilient hardbottom areas. Because the mitigation reef will not be constructed in a location and water depth identical to the ephemeral hardbottom area, no direct spatial replication of the ephemeral hardbottom is possible. Accordingly, caution must be exercised not to generalize the results of this monitoring study beyond the actual study areas (Hurlbert, 1984). Within each treatment area, 10 sampling units will be established. These sampling units, or stations, will be considered replicates in subsequent statistical analyses. The basic sampling unit for the mitigation reef will be the 6 x 12 m (20 x 40 ft) rectangular rock piles that comprise the basic reef structure (see attached construction Drawings). Each unit will be chosen randomly from the mitigation reef template prior to the first field survey and remain fixed for the remainder of the program. Similar sized units (and if possible a similar spatial template) will be established within 1,000 feet of the Mitigation Reef Area or as close as possible in ephemeral and resilient hardbottom areas (two control sites). Units will be marked and relocated with a differential global positioning system (DGPS). Locating, establishing, and sampling ephemeral hardbottom sampling units may be challenging due to wave action and other factors associated with the nearshore environment. Some flexibility will be needed in placing and sampling these stations once the surveys begin. Any ephemeral sampling units that are covered by sand during the course of the monitoring program will continue to be sampled, as that is a characteristic of this habitat.

The framework for the primary study elements are:

- 1) Juvenile Green Turtles
- 2) Attached epibiotal assemblages
- 3) Macroalgal assemblages (for an evaluation of juvenile sea turtle foraging habitat);
- 4) Fish assemblages, and
- 5) Fish predation.

A secondary study element includes qualitative observations of motile invertebrates, and fishes. Details of response variables and sampling methods for each study element are provided in the following sections.

<u>Juvenile Green Turtle Monitoring</u>: Surveys shall be conducted for the occurrence of juvenile green turtles in the mitigation reef area (see Macroalgal Assemblages Assessment, below) and control areas in concert with mitigation reef monitoring surveys. Visual assessments of juvenile green turtle occurrence shall be conducted via "pedestrian surveys" (on-beach and/or reef site visual counts) conducted in association with the regularly scheduled monitoring efforts identified in the plan. Juvenile turtle sittings will be reported to the FDEP in the monitoring reports noted herein.

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<u>Juvenile Turtle Census:</u> Juvenile turtles will be censused along belt transects placed parallel to shore at the artificial reef and reference sites. Belt transects will be 200 m long by 6 m wide. A diver using a diver propulsion vehicle (DPV) will traverse four transects, two inshore of the mitigation reef and two offshore of the mitigation reef. The rapid approach provided by using the DPV will allow the diver to sight turtles that may have been frightened out of view by a normally swimming diver. The diver will traverse each transect looking from side to side and looking under any ledges or overhangs encountered. The numbers of turtles observed will be recorded on waterproof data sheets by species as hatchling, juvenile, or adult. Four belt transects will be censused each at the artificial reef and the reference sites during each semi-annual monitoring survey. In addition, any turtles observed during standard fish censuses will also be recorded.

Attached Epibiotal Assemblages: The basic question is whether or not after a period of time the mitigation reef supports an epibiotal assemblage (e.g., algae, sponges, and corals) comparable to adjacent ephemeral and resilient hardbottom habitats. The statistical null hypothesis for this study element may be stated as follows: there is no effect of reef type on epibiotal assemblage attributes (over time). Response variables for this element will be total biotic cover, cover of major taxa, and total number of taxa. These variables will be sampled within each sampling unit using digital video. A single 12-m (39-ft) transect will be recorded along the long axis of the unit during each field survey. A height above bottom of 45 cm (17.7 inches) will be maintained to ensure adequate image resolution needed for identification of epibiotal organisms. Individual frames from the digital videotape will be subsampled and analyzed with an image analysis system. Percent cover estimates will be made for all identifiable taxa and major substrate types including algal turf, bare rock, sand, and wormrock using random dot overlays. Digital video transects will be collected semi-annually in late spring/summer and late fall/winter for five years unless otherwise determined by the FDEP.

Statistical analyses will consist of univariate and multivariate techniques. Univariate analyses will be performed initially by one-way analysis of variance (ANOVA) using sampling units as replicates within treatments (reef type). After two field surveys have been completed, the temporal component will be incorporated into the analysis using repeated measures ANOVA. Response variables used in the ANOVAs will include those mentioned above: total biotic cover, cover of major taxa, and total number of taxa. Confidence limits will also be calculated and plotted for all response variables. Multivariate analyses will include ordination (multidimensional scaling) and analysis of similarities (ANOSIM) performed on taxa-by-sample data matrices. In these matrices, samples will be coded by treatment (reef type), allowing ANOSIM to serve as a multivariate analog to the ANOVA (Clarke, 1993).

Macroalgal Assemblages (Sea Turtle Foraging): The goal of this element, which is an extension of the attached epibiota element described above, is to provide additional estimates of algal coverage and species composition with better taxonomic resolution than will be obtained from video images alone. This is being done to ensure that the algal forage base used by young sea turtles is adequately characterized. Again, the null hypothesis of no effect of reef type on macroagal assemblage attributes is being evaluated in the statistical analyses. Within each sampling unit, a randomly placed 0.25 m² (2.6 ft²) quadrat will be examined *in-situ* for algal species composition and percent cover. Any species of questionable identification will be

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sampled for laboratory verification. Cover of major classes of algae (turf, macroalgae, and coralline) also will be estimated within each quadrat. Information will be recorded regarding orientation and position (top, side, or base) of each randomly placed quadrat with respect to the limestone boulders in the mitigation reef and with respect to the bottom in the natural hardbottom areas. This approach is a modification of the Atlantic and Gulf Rapid Assessment protocols for assessing macroalgal assemblages, which is currently being used for monitoring attached algae elsewhere in the Palm Beach area (Coastal Planning and Engineering, 2002). Macroalgal sampling will occur for 3 early spring/summer months and once in late fall/winter during each of five study years unless otherwise determined by the FDEP.

Algae Monitoring: The Atlantic/Gulf Reef Rapid Assessment method will be used to assess macro algal assemblages and substrate (http://coral.aoml.noaa.gov/agra/method/methodology) on the artificial reef modules and in reference areas. To estimate algal composition and abundance 25 cm² quadrats will be used. These quadrats will be spaced at 2-m intervals along transects at each study site (sampling unit) within the artificial reef and reference areas. There are ten 12-m transects in each of these areas. If a suitable area is not available at a mark along the transect, the quadrat will be placed on the nearest available space within a 1 m radius of the mark. Generally, a suitable place is considered to have greater than 80% of the area covered by any algae (macro, turf and/or coralline) and no more than 20% of other benthic cover such as bare patches, sand and/or benthic animals (other stony corals, gorgonian holdfasts, sponges, ascidians, etc.). If there are still no suitable areas available, a line will be drawn through the space on the data sheet. For each quadrat, the following will be recorded:

- 1. Substrate type as bare rock, dead worm rock, or rubble.
- 2. Percent absolute abundance of living crustose corallines (solid, calcareous encrusters that are pink or reddish in color, include any that are clearly visible below turf algae or a thin layer of sediment).
- 3. Percent absolute abundance of living fleshly macroalgae (all larger erect fleshy algae, >1 cm in height; macro algae is essentially any alga that you can pick up with your fingers,)
- 4. The average canopy height of fleshy macroalgae present within the quadrat will be measured using a plastic ruler.
- 5. Percent absolute abundance of living calcareous macroalgae (all larger erect calcareous algae, >1 cm in height).
- 6. The average canopy height of the calcareous macroalgae present within the quadrat will be measured using a plastic ruler.

Estimates will not include the percent abundance of turf algae (mostly tiny filaments, <1 cm in height). When assessing corallines and macros, absolute abundances will be recorded from plan view and not include any corallines that are below the canopies of macroalgae. Canopy heights for macroalgae may be different (e.g., 2% tall [5 cm] Stypopodium and 80% short (1 cm) Dictyota). An average canopy height will be determined if needed using several measurements (at least 5).

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Fish Assemblages: The same basic question and null hypothesis described for the attached epibiota and macroalgae is applicable for the fish assemblage. For this element, fishes will be sampled within the same sampling units described above by timed (10-min) swims, which should result in a total count for each unit. At each sampling unit, visually conspicuous fishes will be counted initially; using a roving fish count method. Care will be taken not to recount highly mobile or curious (following) individuals. Following the initial count, any ledges, crevices, or holes present will be searched carefully (using underwater lights if needed) for cryptic and newly settled species. Any newly settled fishes that cannot be reliably identified in the field will be collected for laboratory identification. The area searched will include the 6 x 12 m (20 x 40 ft) sampling unit and the water column above. During visual censuses, all fishes encountered will be recorded by life stage category (newly settled, juvenile, or adult). Samples collected this way will provide density and relative abundance estimates for reef-associated species. Water column species such as herrings, sardines, and scads will be counted but may be omitted from some data analyses. Fish censusing will take place for 3 months in late spring/ summer and once during late fall/winter months (as conditions allow) during each of the five survey years unless otherwise determined by the FDEP.

Individual counts from each unit will serve as replicates in statistical analyses that will be similar to those described above for the attached epibiota. Response variables in ANOVAs will include number of species, number of individuals (or densities), and numbers of selected species/life stages. Ordination and ANOSIM will be performed on species-by-sample matrices as described above. Life stage information for key species will be plotted as frequency of occurrence and proportional abundance by category among reef types. Data on all species classified as newly settled will be plotted to determine spatial and temporal patterns of recruitment among reef types. Finally, measures of taxonomic distinctness (Clarke and Warwick, 1999) will be calculated to estimate diversity at each treatment area.

<u>Fish Predation</u>: The primary question investigated under this monitoring element may be stated as follows: Are there any differences in the numbers and kinds of fish predators associated with the different reef types? The statistical null hypothesis of no effect of reef type on the abundance and kinds of predatory fishes will be evaluated under this monitoring element. It is assumed that abundance of predators will be an indicator of predation pressure on juvenile and newly settled fishes within each treatment (and sampling unit). To evaluate the hypothesis, data collected during the fish censuses described above will be used to estimate numbers (and densities) of predators at each sampling unit. Common predators will be classified as stationary (e.g., snappers, lizardfishes, groupers, hairy blenny) or roving (jacks and mackerels) to facilitate comparisons. The focus of the analyses will be on selected stationary predators most likely to prey upon young fishes.

A second question is whether or not the abundance of predators is correlated with structural complexity of the sampling units (e.g., Buekers and Jones, 1997). The statistical null hypothesis for this question is that structural complexity of the reef types has no effect on predator abundance. To estimate structural complexity, "rugosity" measures will be taken at each sampling unit using the standard chain/transect method (McCormick, 1994).

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Data analysis will include ANOVA on the abundance of all predator classes and selected predatory species across treatments (reef type). To assess the extent to which predator abundance varies with habitat complexity, simple linear regression will be performed using rugosity as the independent variable and predator abundance as the dependent variable. Multidimensional scaling and ANOSIM also will be performed using predatory species-by-samples matrices.

<u>Qualitative Observations</u>: In addition to the primary study elements, qualitative observations will be made on motile invertebrates and conspicuous attached epibiota with the goal of constructing a phylogenetic list for all treatment areas. A similar list will be kept for fishes not observed during formal sampling. Particular attention will be paid to recording any sea turtles, economically important fishes (snook, tarpon, pompano), and invertebrates (spiny lobster) observed.

<u>Hardbottom Mapping</u>: To verify that the project will not have an adverse affect on the natural nearshore reef located approximately 1,000 ft. to the north of the project, underwater surveys and aerial mapping with video documentation, of the nearshore hardbottom located north of the project area shall be taken immediately prior to construction, immediately after construction, and annually thereafter for a period of five years unless otherwise determined by the FDEP. DGPS navigational coordinates of the dives shall be referred on the video transects and overlaid on recent aerial photography.

Reef Mapping: Underwater surveys and aerial mapping of the mitigation artificial reef, with video documentation, shall be taken immediately prior to construction, immediately after construction, and annually thereafter for a period of five years, unless otherwise determined by the Department. DGPS navigational coordinates of the dives shall be referenced on the video transects and overlaid on recent aerial photography.

Reporting: Annual monitoring reports will be submitted 90 days following the final summer monitoring event within each of 5 monitoring years. Reports for Years 1 through 4 will include preliminary data analyses, maps of geo-referenced sampling units and associated data, and raw epibiotal and fish assemblage data. The final Year 5 report will be submitted 120 days following the final monitoring event and will include, but not be limited to, final data analyses, synthesis and interpretation of results, and final mapping products. All reports will be submitted in digital and hard copy.

Each Monitoring Report will summarize the results of the biological surveys and the monitoring of the mitigation areas and identify any adverse impacts that would be attributable to the project. Each report will compare the current conditions to:

- (a) the pre-construction baseline survey
- (b) the first postconstruction survey, and
- (c) any previous annual survey(s) (where applicable).

Each report shall contain an analysis and discussion of the video documentation in regards to any burial, subsidence, sedimentation, or trauma that has affected the marine algae, coral, sponges, or other related biological communities. In addition to the standard monitoring of

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physical stability and taxonomic lists of species, the monitoring report will include ecological comparisons to adjacent hardbottom reefs that examine variables such as indices of recruitment for larval/juveniles, predation rates and prey vulnerability, and size structure of fish and selected invertebrates.

Bathymetric Survey: A bathymetric survey will be performed at one, three, and five years post construction to provide an accurate depiction of bottom elevations throughout the Artificial Reef. A State plane coordinate-based grid (NAD 1927) will be established to completely traverse the artificial reef area. The bathymetric survey lines will be spaced at a maximum of 50 feet intervals. The survey lines will run parallel and overlap the bathymetric survey lines depicted on the as-built drawings. The bathymetric survey will be performed by employing a fully automated hydrographic survey system operated from a stable, shallow draft survey vessel with a semi enclosed cabin, for protection of the onboard survey equipment. Navigation and positioning for the offshore survey will be accomplished using a real time differential Global Positioning System. The navigation and fathometer systems will be interfaced and the data integrated in real time. All data will be electronically recorded for post survey data reduction. Bar check calibration of the fathometer will be taken at the start of the day, periodically throughout the survey, at the end of each survey graph paper roll, and at the end of the day. Tide readings will be taken at a minimum of 15 minute intervals during the survey. A 24" X 36" survey plan view drawing will be prepared with: a plot of the tide adjusted bathymetric data; a reference State plan coordinate grid; the limits of the Artificial Reef Mitigation Area Consent to Use Sovereign, Submerged Lands; and, the limits of the artificial reef.

Video transect lines will be performed at a maximum spacing of 50 feet along the lengthwise axis of the Artificial Reef Area. In addition, transects transverse to the axis of the Artificial Reef Area will be performed at a minimum spacing of 100 feet. The transects will be performed utilizing an integrated Video Mapping System (IVMS) or equivalent. Video data will be collected by a diver biologist towed behind the survey vessel with an underwater low light, high resolution color video camera. The video tape recording will include: an audio record of verbal comments and observations by the diver/biologist; and, a digital record of the date, time, transect identification information, and State plane coordinates. Based on the video transects coordinates, the Artificial Reef Area limits will be subsequently superimposed onto the bathymetric survey to verify that the required artificial reef area has been created and provides the appropriate average relief (exposure) as indicated in the regulatory permits.

<u>Mitigation Reef Modifications</u>: If the five-year monitoring survey indicates a reduction in the extent of the artificial reef as compared to reduction in adjacent historically exposed hardbottom (control areas), a plan shall be submitted to the Department to make up the difference with implementation of the plan once approved by the Department.

Proposed Performance Criteria

- After one year colonizing epibiota (turf algae, bryozoans, hydrozoans, and tunicates) will be present on the mitigation reef.
- After five years biotic cover on the mitigation reefs will be at least 25%.
- After five years major epibiotal groups (macroalgae, sponges, corals, and tunicates) will be present.

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- After five years the number of fish species present will be at least 75% of the number of species present on adjacent natural reefs
- After one year the distribution of fish life stage categories will be comparable to the distribution of fish life stages found on adjacent natural reefs.
- After one year members of common fish families such as grunts, porgies, damselfishes, and wrasses will occur on the mitigation reef.

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